

KLEBS

HIST. PATH.

COPYRIGHT, 1917

THE HISTORY OF INFECTION

By ARNOLD C. KLEBS, M.D.

WASHINGTON, D. C.



REPRINTED FROM SUMMER NUMBER, 1917

ANNALS OF MEDICAL HISTORY

PUBLISHED QUARTERLY BY PAUL B. HOEBER

PAUL B. HOEBER, 67-69 EAST 59TH STREET, NEW YORK

THE HISTORY OF INFECTION¹

By ARNOLD C. KLEBS, M.D.,

WASHINGTON, D. C.

NOT only among the Greeks and Romans who still are our principal schoolmasters, but long before them there existed in human language a term to designate the process of infection. It did not always have exactly the same significance which it now has. Tradition preserved for it a certain basic meaning; and convention, according to varying necessities and changing interests, modified its application. This is only the natural variation to which all terms are subject and one of the reasons why it is so difficult for us to enter into the thoughts and activities of former generations and fully profit by their experiences.

When the Roman used the verb "infectere" it conveyed to him not only the literal sense of putting one thing into another, but with the qualification that the "infected" object is altered in appearance or effect and chiefly so as to render it unpleasant, harmful or corrupted.² Now, this corresponds in general to our own use of the word and indeed one might think that we chose it for that very reason, making it only more precise and limited. As a matter of fact we had no choice. The term came down to us gradually through all the intervening generations, even preserving its Latin form. It is evidently the importance of the underlying idea which it expresses

intelligibly that has preserved it, and this idea is neither Roman nor Greek, but simply human. It offers an appropriate word-picture for something of daily incidence and vital importance. It relates the cause with the effect and thus becomes the word-symbol of a primitive ætiologic concept. Words of this kind have a much greater vitality than the more artificial nomenclature of philosophy and science.

Since we have become acquainted with microorganisms and their rôle in diseases, ætiologic research, because of its tangible object, has exerted a determining influence on medicine. It has gone almost to the extreme of making ætiology and bacteriology synonymous terms. Infection to-day means, if we take it in the broad definition of Hektoen, "the entrance into the body of living agents, capable of multiplication, most commonly microbes, which then cause disease." The microorganism as the determining factor of infectious diseases, the specificness of the infection and the invariability of microbic species make this the dominant theory of the day in medicine. Its profound influence is felt in private and public life to a degree unparalleled in the annals of human society. So dominant is this doctrine that the question is hardly ever asked: might there not be, apart from the microbe, pathogenic influences of equal if not of greater importance?

Even those who vindicate for modern scientific research its freedom from dogma (Hamilton) adhere to the all-importance of the living agent in the causation of disease. The others, the followers of Koch, whose labors, they say, have brought the question to "a certain and unequivocal conclusion,"

¹ Subject of an address delivered before the Biological Club of the University of Chicago and the Historical Society of Washington University, St. Louis, in December, 1916.

² The adjective and noun (*infectus* and *infectio*) had more the sense of our "ineffective," while "*infectivus*," at least in Vitruvius, is the thing altered, infected, particularly dyed or colored.



proclaim proudly that the doctrine, even in its most restricted sense, ought to have been long ago "established as a fixed dogma" on the basis of historical tradition and by every-day observation.³ Here we have in modern times a contrast between empiricism and dogmatism which in the past has led to so many wasteful and sterile conflicts. It is immaterial whether the basic theory on which both are agreed was obtained by syllogistic reasoning or by experimental demonstration, neither is concerned with the continuous reality as it appears to immediate intuition; for practical purposes this is broken up into elements, and fixed by verbal symbols (or images of objects) later to be artificially reconnected.⁴

Most of the historical surveys of the doctrine of infection are nothing but panegyrics of the current doctrine, showing past errors or an assumed evolution from vague unconscious gropings towards that final perfection represented by modern achievements. While entirely legitimate, this kind of historiography can give only an inadequate understanding of human thought in the past and no clear outlook into the future. The higher task of history is to study critically the ideas of man about living nature, in the same way that the biologist studies the various phenomena of the organism itself, to promote the understanding of basic principles. If we study the records of the past with this aim before us, we perceive that the concept "infection," although assuming, from time to time, for practical purposes a varying, transitory significance, tenaciously retains a fundamental and primordial relation to disease, possibly identical to the one ingestion holds to growth and sustenance, or fertilization to the propagation of the species. Such generalization may be deemed unscientific and

contrary to the admonition that the historical student should record rather than interpret. But there can be no doubt that the endeavor to disentangle from history the leading and connecting threads adds zest and vitality to the search and no harm is done provided true facts are given without distortion.

The *Annals* have brought in the last number an illuminating study by Dr. and Mrs. Singer on Fracastoro, the first clear exponent of the theory of infection as we now understand the term. The essay shows very well how the mind of a *cinquecento* scholar, unaided by the microscope and bacteriologic technique, could formulate what we believe has now been determined as a scientific fact. But there can be no question that the same idea was in the minds of uncounted generations before Fracastoro. To analyze some expressions in available literature that seem suggestive in this direction is the task I have set for myself in the following.

BABYLONIA AND ASSYRIA

Civilizations which have endured for such long periods as did those of the ancient Babylonians and Egyptians must have been founded and advanced by very practical people. Their efforts and thoughts, while in form differing from ours, must have been directed to the realization of very similar aims. Their evident success, if nothing else, must command our attention, although some are inclined to dismiss as superstitions most of the ideas we encounter among them. Perhaps it would be more profitable if we used the word "superstitions" in Lowell's sense as marking the world's "unfinished business." Are we not apt to overlook the fact that the primitive man, when he tries to promote his understanding of the world by attaching a name or some figurative symbol to the invisible power which he feels affects him in some way,

³ Kolle in "Handbuch der Mikroorganismen" by Kolle and Wassermann, 2nd ed. I, 869, 872.

⁴ See Bergson: *Mind and Matter*. Lond., 1911.

does nothing essentially different from what we are doing all the time? "Seeing is knowing" guided him as it guides us, and the superstitious awe of which we hear so much blinded him far less than is usually thought. Beneath the complex texture of his mythology we find, if we only look for it, frequent evidence of most minute observation and the utilization of experiment.⁵

Theurgic and numinal concepts form the basis of the nosological nomenclature of the ancient Babylonians and Assyrians. The study of cuneiform inscriptions has opened our eyes to a new world. The texts which deal with incantations, divinations, conjurations (exorcisms) and the like contain a great deal of information on medical subjects. The priest, who filled the place of the physician, as so often in history, used these texts as a sort of practical guide book in his daily routine. They were to lead him to diagnosis, prognosis, prophylaxis and treatment of human ills. The compilation of the most important ones can be traced to the non-semitic priests and magicians who practiced their craft before the advent of the semitic Babylonians (dated variously between 5000 and 4000 B.C., or roughly, before 3000 B.C.). The excavations of the great library of Asurbanipal (668-626 B.C.) at Nineveh brought copies of them to light.

For infectious diseases the most important series is that of incantations against the special disease demons and fever sickness (*ekimmu* and *ašakki maršūti*) or the "incantations against the appearance of the dead." Consciousness of regret and fear, evoked by the memories of those that have passed away, sublimized by the mystery of death, these are the principal sources of the belief in the troublesome ghost. The idea of the entrance of the demon into his victim is not always clearly expressed. The incantation, which is really the prayer of a

troubled soul, has the sense: "Let them accept this offering and leave me in peace."

In the divination series the same ideas prevail. They form a minutely worked out system of prognostics, based partly on observation, partly on hypothesis, intended to serve individuals as well as the king or state. The elaborate descriptions of the birth omens and liver omens have evoked great medical interest because they revealed an unexpected knowledge of anatomical detail. From one of the liver-texts we learn of the *mangu*-disease, an infection of the throat which seems to have appeared as an epidemic, something like diphtheria, and another of the face which has been identified as erysipelas.⁶ There is naturally a great deal of arbitrariness in this nomenclature of diseases in which it is often difficult to distinguish whether the demon or the disease that he is supposed to have produced, is intended. Still, whether demon or disease, we have quite a number of names which are thought to specify infectious diseases as, for instance: *Bennu*, *sassatu*, *sakikku*, *batu*, *mursu*, *si-ib-tu*, *ummu*, *buntu*, *li'bu* and in a class by themselves *sidanu* and *miktu*.⁷

While religious cult, just as scientific research, produces a large and somewhat mysterious nomenclature, the language used to define personal property in sale or purchase strives towards clearness and circumscribed precision. The right of the purchaser of a slave to return the same to the seller at the original price after a certain, stipulated period, in case of an illness or defect which was not obvious at the time of sale, was recognized in the famous law

⁵ Thus we see, for instance, on various Assyrian monuments some divinities depicted in the act of fertilizing manually the flower of the date palm.

⁶ Cuneiform Texts, Part xxviii, 43; and for many further details the works by Jastrow: "The Civilization of Babylonia and Assyria," and "Religion Babyloniens and Assyriens," in three volumes, which contains translations and discussions of numerous texts (incantations and divinations). Phila., 1915.

code of Hammurabi.⁷ Slave contracts based on this law have come down to us in great number not only from Babylonian, but also from Assyrian, Persian, near-Asiatic and finally Greek times. Since the diseases are usually stipulated by a name in these contracts and their most striking traits defined by the practical exigencies of the contract, it was hoped that their study would perhaps bring out more precise details about the ancient knowledge of a circumscribed group of diseases. As a matter of fact it was found that also here accurate identification offered great difficulty and that it was much wiser to be satisfied with the general information obtained.

It is fairly generally agreed among experts that the two names *bennu* and *sibtu* which are found most frequently in these contracts were meant to designate those diseases or defects whose occurrence could invalidate the sale. Non-medical Assyriologists were quick to identify them in various ways. Fever and ague (Harper, Jensen), syphilis (Ungnad) and lepra were in turn proposed⁸. Sudhoff, by a very interesting and ingenious argument based upon a mass of corroborative evidence, has come to the rather startling conclusion that both terms together were meant to indicate a seizure of epilepsy. This would put the subject apparently out of consideration in this place. But epilepsy and other psychotic and neurotic affections have been regarded through long epochs as caused by infection, and the term psychic infection is occasionally heard in our own day, so that we may be permitted to devote a little time to Sudhoff's translation of *bennu* and *sibtu*, inasmuch as the material he adduces allows possibly a different interpretation.

⁷ 2267-2213 B.C. See Sudhoff, *Arch. f. Geschichte d. Med.* 1910-11, iv, 353. cf. Johns, C. H. W.: *Assyrian deeds and documents on transfer of property*, 3 vols. Cambridge, 1901, iii, 394.

⁸ See Kohler and Ungnad: *Assyrische Rechtsurkunden*, Leipzig, 1913.

Assyriologists derive the word *bennu* from a Sumerian ideogram which stands for muscle or tendon, and hence they give as the literal translation "the disease of the muscles." In later contracts, made by Greeks in Asia Minor, Sudhoff found the word *ἱερὰ νόσος* ("sacred disease") in the same place inserted with one or two other names of diseases. This he considers definitely identified with epilepsy and hence he concludes that in the Babylonian contracts the word *bennu* also is meant to designate a disease characterized by spasmodic attacks which incapacitate the victim and by periods of latency might deceive the purchaser. This is quite plausible, but it might be objected that the muscle spasm would not necessarily be the most striking symptom of the attack so as to impose the special name, also that we have no evidence that epilepsy occurred frequently enough to make a special legal provision against it desirable. However this may be, only Assyriologists assisted by medical men can decide the matter. There is, however, a disease the enormous frequency of which in antiquity is abundantly demonstrated by palæo-pathological findings and which, so far as I know, has never been mentioned in connection with *bennu*—I mean *osteo-arthritis deformans*. From the findings in Egyptian mummies we know that it led to marked deformity, such as we see no more, and also that it attacked already relatively young individuals. That it might have appeared as a "rheumatic" muscle disease any modern sufferer of the trouble will readily testify, and thus the terms *bennu* and *rheuma* are about on a par as regards ætiologic lucidity.

Whether the word *sibtu* stands for a different disease from *bennu*, or whether it simply means, as Sudhoff thinks, "seizure" or "attack," derived from the verb *sabatu* "to grab, to seize," is still an open question. Undoubtedly it has been used in various senses, but it seems quite established

that it designates rather a general concept than a special object and that this corresponds to the Latin *inficere* is more than likely. Very similarly the Greek *ἐπαφή* is used later in connection with lepra, the verbal derivative of which Thucydides employs to designate the infection, in his famous account of the Attic plague, so that Sudhoff considers the Greek word a literal translation of the Assyrian term. The Hebrew word *nega* very similarly determines *saraath* and the two together are translated in our Bible as "the plague of the leprosy."

A series of Babylonian tablets is devoted to lists of animals and plants showing, not only a considerable knowledge of fauna and flora, but also that degree of careful observation necessary for a systematic classification. The latter does not always correspond with ours but that need not disturb us unless we are ready to assume that our classification will survive the next 5,000 years. The Babylonian recognized perfectly well the rôle which certain of the smaller animals played in those diseases which for some reason or other we consider, as parasitic, different from the other infectious diseases.

Dr. F. von Oefele has made a special study of Babylonian entomology and with great courtesy he has put his notes on the subject at my disposal.⁹ The texts begin with the large class of *zumbu*, the fly, in which are enumerated several diptera and hymenoptera. Their names are determined by those of their various hosts and also by water, stone and other objects, or foods for which they showed a predilection. The fly as the symbol of the god of destruction and pestilence, Nergal, appears quite often in pictorial representation as a special emblem, so for instance on a seal cylinder in the collection of the late J. P. Mor-

gan.¹⁰ The next class is formed by the various bugs which as hemiptera, with some 50,000 species, threatens to drown the modern entomologist. Under the name *kalamatu*, 18 different lice are recorded. Some of them figure as worms, which need not astonish us, because even quite close to our time they have been frequently described as such.¹¹ These lice are again named by their habitat beginning with *kalamatu kaḳḳadi*, the "head louse." There are three hypothetical kalamates which are said to produce internal disease; they are: *mikkana*, *tultu* and *mubattira*. *Tultu* is the best known. It is the worm cause of dental caries and toothache and as such became the object of a great Babylonian incantation. This ætiologic concept we can follow in an enormous literature way into the 18th Century. Dr. von Oefele also calls my attention to the fact that in the texts of the North American Dakota Indians the same concept is found.¹²

BIBLICAL PEOPLES

Many cultural streams have crossed each other in the lands of the easternmost corner of the Mediterranean basin with which the

¹⁰ Nergal is represented in the company of 14 demons over which he has command. They represent various evil influences, some of which surely are diseases, especially fevers. Ungnad in Gressmann: *Altorientalische Texte und Bilder*, I. p. 69 gives their names as follows: 4. *mutabriku*, 5. *sarabdu*, 6. *rabisu*, 7. *dirit*, 8. *ibitu* (?), 9. *bennu*, 10. *sidanu*, 11. *mikit*, 12. *bel-ubri* (?), 13. *ummu*, 14. *libu*. *Bennu* here heads five others which all stand for various degrees of heat, indicating possibly feverish diseases. (See Sudhoff, *op. cit.*, note 7.)

¹¹ "A lous is a worme with many fete & it cometh out of the filthi and onclene skynne . . ." *Book of the Quinte Essence* (ed. Furnival) p. 19.

¹² He adds: "It is Mongolian in common; from the time prior to the separation of Mongolian and Indian. It entered Babylonian medicine through the Hittites, whom I consider with the Etruscans and other peoples as Mongolian, split off from them somewhat like the Huns."

⁹See *Cuneiform Texts*, Part xiv, London, 1902.

Bible has acquainted us. Of course it has been intensively studied, but still many puzzles remain to be solved. It was a revelation when not long ago, in Crete, traces of a very high (Minoan) culture were found, one which antedated considerably that of Mycenæ, Troy and of classic Greece. We have also not yet found out about the Hittites, and much remains equally uncertain about the Philistines who seem to have come from Crete. It is in the accounts of the wars between the Jews and the Philistines that we find an early reference to our subject. (11 Sam. ii 3.) When the Israelites were hard pressed by the Philistines they sent, as a last resort, for the Ark of the Covenant to be brought from Shiloh to the front. The Philistines speedily captured it and took it in triumph to Ashdod where it was exhibited in the temple of Dagon. The result was that the statue of Dagon fell down and broke its hands. Then the plague broke out in the town and spread along the coast. This "plague of emerods" is usually identified with the bubonic plague. The subsequent spread of the plague is expressly connected with the arrival of the ark in those three places to which it was in turn removed. During its sojourn of seven months in Philistia it must have done a great deal of harm, and at Ekron, its last station, it was finally decided on the advice of the "priests and diviners" (vi, 2) to send the ark back to the Israelites with an appropriate trespass offering. This was to consist of five golden emerods and five golden mice "according to the number of the lords of the Philistines." These offerings, the text states (vi, 5), were to represent "images of your emerods and images of your mice that mar the land . . . to lighten his hand from off you, and from off your Gods, and from off your land."¹³ These offerings were to be placed

¹³ This is the only passage from which a concurrent plague of mice might be inferred. (cf. Macalister: *The Philistines*, London, 1914, p. 47.)

into a separate coffer beside the ark,¹⁴ and to be delivered at the frontier to "those of Beth-shemesh." Here once more the ark proves troublesome, killing some 50,000 people "because they had looked into the ark" (vi, 19). This last outbreak of the plague among the Israelites themselves would seem to emphasize the authenticity of the story. It was a plain and recognized case of infection *per fomitem*, independent of theurgic influence.

Another epidemic, several hundred years later, is also briefly mentioned in the Bible (11 Kings xix, 36). This time the "Angel of the Lord" smote 13,000 Assyrians of the invading army of Sennacherib (705-681).¹⁵ Herodotus (ii, 141) gives more details about this plague and connects it somehow with mice. According to an Egyptian tradition, the Assyrians were decimated through the intervention of the God *Ptah* in the rôle of a pestilence deity. This *Ptah* had a temple at Thebes where he was represented holding a mouse in his hand. We see in all these tales, the mouse creep in somehow. Offord¹⁴ states also that votive mice modeled in silver were found in a river on the Syrian coast, near Sidon, and that mice are carved on Phœnician and Punic monuments. A deity of the latter, *Eshmun*, was, it appears, equated by the ancients with *Æsculapius* and that his cult was very similar to that of the "Smintheus" who inflicts the pestilence upon the Greeks before Troy (*Iliad*, i, 53). Smintheus is the "mouse-god" alternative of Apollo. Other gods with mice attached to their images or receiving offerings of mice were *ATM*, the associate of the hawk-headed sun god *RA* of Egypt, the *Reseph* (Dagon?) of the Philistines, Phœnicians and Cypriotes, according to Offord, worshiped also by Hittite and Syrian tribes.

¹⁴ Cf. Offord in *Science Progress*, London, 1916, x, 570.

¹⁵ Isaiah xxxvii, 36: "when they arose early in the morning, behold, they were all dead corpses."

One should think that the correlation of plague and mice, evidently noticed in such remote ages, would have impressed the bacteriologist earlier, inasmuch as we can follow it to the threshold of our times as a historical common-place. When Nicolas Poussin in his famous painting, now in the Louvre, of the "Pest of the Philistines," has rats among the crowd of victims in front of Dagon's temple, he found more justification for doing this in practically all the accounts of plague that he might have consulted, than in the rather meager evidence of the Bible. But it would not be sound reasoning to conclude that all this historical evidence must be taken as vague anticipations of present conceptions. Even the use of mice or rats as emblems of plague divinities, or their models as votive offerings is not necessarily conclusive. One must not forget that all these divinities were the controlling forces of all kinds of destructive calamities, for the prevention or removal of which they were implored. The mouse, all by itself, represented one of the most dreaded plagues to an agricultural people and thus may have been symbolized without any reference to the plague in man. Aschoff (*Janus*, 1900, v) tried to get to the bottom of the question why the mouse should have symbolized the plague. From a comparison of the passages in the Vulgate and the Septuagint he suggested that the votive offering might simply have attempted to reproduce the size and shape of the bubo. But from the passage in 1 Sam. vi, 5 it is quite clear that models of both bubo (emerod) and mouse were offered, each apparently for a specific purpose. The custom of offering in sacrifice to a deity models of organs or of symbols of disease is also very ancient and, as is well known, persistent in our day. It is of great interest and has an indirect bearing on our subject because these models were probably thought to draw away, specifically, the anger of the deity from that part of the patient's anatomy.

The Hebrew "scapegoat" and the Greek "pharmakos" are simply variations in form of the underlying idea.

More important than the decision of the question whether the Hebrew recognized the relation between mice or rats and the plague is the very clear account given of the transmission by fomites and the comparative silence about direct transmission from individual to individual. From the sanitary point of view the decision of the relative importance of these two factors has a definite significance and as it is still under discussion it is interesting to note that the ancient Hebrew apparently decided it in favor of those moderns who oppose the extreme contagionist stand-point in plague prophylaxis.¹⁶

The concepts of the insect pests among the Biblical people are largely derived from the Babylonians. Thus the fly, the mosquito and other diptera play also with them a rôle in cult and elsewhere. Ekron, which we have already mentioned as one of the stations of the Ark in Philistia, held an ancient and famous shrine dedicated to *Baal-zebub*, which name, literally translated, means the "Lord of flies." Macalister identifies Ekron, not with Akir as is usually done, but with the modern Dhikerin farther south, near which still exists Deir edh-Dhubban, "the convent of the fly." The shrine of Baalzebub was so famous for its oracles that the Jewish king Ahaziah, when ill, sent to consult it, disregarding thereby the general prejudice of the orthodox against foreign divinities (11 Kings i). This Baalzebub, who only later in official demonology became one of the governors of the Infernal Kingdom of Lucifer, represents, as fly-averting, a very ancient and widely prevalent anthropomorphic conception. He is surely a Babylonian importation, probably even older. He and his female counterpart *Ashtoreth* (Astarte, Ish-

¹⁶ See G. Sticker. *Wien. klin. Rundsch.*, 1898 and his exhaustive monograph "Die Pest," Giessen, 1908

tar), so popular among Assyrians, Phœnicians and Canaanites, proved very tempting to the Jews whose leaders painted them so black that their devilish reputation has long survived. The deep appeal which these, we may call them ætiological, divinities exerted upon the human soul, is a very interesting fact to note, as well as the opposition which they encountered from the learned. It is also known that Hippocrates had to warn his pupils against the demoniacal theory of disease. Baalzebub of Ekron and the BaalBerek (Berith) of Shechem (in the Talmud) was known to the Greeks as the Βάαλ μύϊαν and probably directly transmitted into their own cult as the Olympian Zeus Apomuios, of whom Pliny speaks in his Natural History (xxxix, 34), where he also mentions the use of fly ashes in the treatment of *alopecia* "to drive away the fly."¹⁷ All these are only echoes of the Elamite and Babylonian rites, brought out by the French excavations at Susa, fixed by the fly-emblem already alluded to. The curious persistency of the popular association of health and fly is illustrated by a pretty story Macalister (l. c.) tells about the healing spring of St. Michael in Kirkmichael (Banffshire) which, in popular tradition, had always been presided over by a fly and the neglect of which as late as 1820 was deplored by an old man who "in the days of his youth enjoyed the pleasure of seeing the guardian-fly." Deeply rooted in the folk soul is this old and ever-young concept of this relation of fly and health; and as we watch the "burnt-offerings" of hecatombs of trapped flies rising to the skies from the camp fires of the U. S. Army we do not seem to be so very far from Babylonia.¹⁸

More closely in concordance with our views on infection are the prophylactic laws against the *saraath* (the collective name for lepra and similar diseases) which are re-

¹⁷ See M. Hoefler: Die volksmedizinische Organotherapie. Stuttgart, 1908.

corded in the famous chapter xiii of Leviticus, a book which is known to date from the Babylonian phase of the Jewish people. It became the prototype for similar sanitary legislation close to our own times and led to the provision of institutions which we have every reason to admire. It is indeed the current opinion that the wide distribution of the leproseries throughout Europe was mainly responsible for the gradual disappearance of lepra toward the end of the Middle Ages. It is difficult to understand how again and again the opinion can find utterance that these measures were not based on the fundamental recognition of the infectiousness and transmissibility of the disease, because of the demoniacal prepossessions in the minds of the Jewish law-givers. It is not my intention to enter into this subject fully although in the concatenation of facts it is one of the strongest links. My desire is to bring out facts which are not so clearly self-evident. Morris Jastrow, Jr., has recently discussed the subject (*Jewish Quarterly Rev.* IV, 357). His view is that the laws are mainly based on the demonistic theory of disease which must not be confounded with our own bacterial theories and that the remedies were not used against the disease but against the demons to whom they were distasteful — pharmacology gradually evolving out of demonology. This is, of course, one way of looking at the matter, but it fails to go to the core of it. J. H. Alexander, on the other hand (*Med. Press and Circular*, London), following Clerk Maxwell's famous example, substitutes in certain ancient accounts bacteriologic terms for the demonistic ones. Finding them to fit well, he asks whether this is due to mere chance or whether the Ancients did not anticipate to some extent

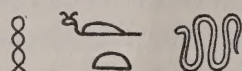
¹⁸ That in our days grave pathogenic possibilities of the fly are recognized is clear from a large special literature which has been admirably reviewed by Henry G. Beyer: The dissemination of disease by the fly. *N. Y. Med. J.*, 1910.

in their crude ideas and beliefs the theories of modern science.

EGYPT

The views the ancient Egyptians entertained about diseases and their causes are much better known than those of the peoples we have just discussed. The differences are in form rather than in substance. I shall content myself to select only a very few examples out of the rich harvest of archeologic research.¹⁹

The disease-making possibility of the worm seems to have been uppermost in the Egyptian mind in all times. Worm diseases being very prevalent, this cannot astonish. But that the relation of worm and disease should have been established in ancient time in those cases where only the minutest examination can reveal the parasite, would seem remarkable indeed. Herodotus gives an account of a regulated inspection of the meat which was destined for sacrifices. It shows among other things that the inspector, the priest, was on the look-out for such small invaders as the cysticercus. When only parts of the animal were sacrificed, the rest was available for consumption and so the inspection may have had a direct hygienic intent. But meat was not the main diet of the Egyptian. Cereals, vegetables and fruits were the staple foodstuffs, but to them must be added as of considerable importance the air-dried fish, at least for the early Egyptian. This latter fact allows us to identify a tape-worm for which there is a hieroglyphic sign:



i.e., the *pend*-worm, with tolerable probability as the *botriocephalus latus*, whose cysticercus lives in freshwater fishes. The

¹⁹ For further detail see the brilliant articles by F. von Oefele: Studien über die altaegyptische Parasitologie. *Arch. de parasitolog.*, Paris, 1901 and 1902, iv and v.

tænia solium and other cestodes may of course have occurred also, but for the former this is not very likely since pork as a whole was despised as food.

The Egyptian anæmia, still very fatal, seems to have been known to the ancient Egyptian. At least a description in the Papyrus Ebers has been interpreted in this sense. Here it is stated that the fatal disease was sent by the God of Death, āāā by name, to both sexes, causing abdominal and other pains, bloody discharges. As its immediate cause the worm *Neltu* is named. Scheuthauer, Joachim, Finlayson identified this āāā-disease with the fatal anæmia caused by the *ankylostoma* or *uncinaria duodenalis*, i.e., our hookworm disease. This restricted identification has lately been disputed on very interesting grounds.²⁰ Pfister opposes very rightly the tendency of identifying too closely with modern concepts those ancient descriptions which covered broad complexes of symptoms and not pathologic entities. He demonstrates that very similar symptoms are caused by the *schistosoma hæmatobium* in that equally fatal disease *Bilbarziosis*, which attacks in some places as many as 70 to 80 per cent of the population (as against 25 per cent of ankylostomiasis). That *Bilbarziosis* most likely entered into the concept of the āāā-disease, Pfister sees in the fact that in the hieroglyphic sign for the āāā-disease, the phallus is the determinative:



If this is so, it would indeed be good evidence, for as he shows in typical pictures, the urethritis with subsequent enormous tumefaction of the penis, as the most striking symptom, would have amply justified the use of this determinative. No other than these two worm diseases seem to have been considered

²⁰ E. Pfister: Ueber die āāā-Krankheit der Papyri Ebers und Brugsch. *Arch. f. Gesch. d. Med.*, 1912, vi, 12.

and around this of course hinges the whole question as to what diseases are comprised in the *āāā*-disease, a question which only the Egyptologists are competent to decide.²¹ If the Egyptians could detect the worm as the cause of the disease, it is astonishing indeed, given its small size (about 10 mm. length, the schistosoma being a little longer than the ankylostoma) and the fact that it is not readily observed in the excretions.

CLASSICAL ANTIQUITY AND AFTER

As we leave the era of these remote peoples and approach the one we know better and recognize as the basis of our culture, we seem to notice the gradual development of circumscribed, almost tangible, notions about the subjects which have occupied us. There we saw man apparently satisfied with the vague connection of primordial ideas, apprehended more by feeling, by intuitive perception, than by reasoning. Here he seems to have discovered systematized thinking as a new instrument by which he could with certainty approach the riddles of the material universe and of life, in order to satisfy that new craving for knowledge which had come over him. We saw how the Babylonian had already begun to classify his observations. Now Greek and Roman begin to classify their thoughts and to write them out; not any more as a solemn religious rite, but for the dissemination of what they regard as a record of their wider and more conscious experience. This, broadly speaking, marks the principal distinction of that epoch which we call classical, as the prototype of our own civilization. All becomes very complex suddenly. Fixed concepts based on intricate reasoning multiply with the individualities of the thinkers. And as we project ourselves into that life, we

see the analogies and resemblances with our own, passing over the essential differences determined by their closer relationship to and dependence on the older cultures; and we see only the dawn of our civilization and the birth of our science, of progress.

What profound differences between these two "classics." The Greek, in his gay, cheerful attitude towards life, exquisitely receptive to the beauty of form, of color and of thought, casts the forces of nature into beautiful anthropomorphic shapes. The same sense for proportion and harmony which we admire in the artistic products of his hand characterize equally those of his mind. Of much sterner stuff the practical Roman. He takes himself and life more seriously, he has a purpose: action and power; art and thought are there only to serve it, they have to be fixed and codified, made into law. Disease for the Greek is a disturbance of the beautiful harmony of health, he thinks it out on those lines and tries to reestablish the harmony. Hence hygiene is the keynote of his medicine. The Roman proudly refuses to consider disease except when its palpable existence forces him to it. Then only and reluctantly he takes the most necessary steps. There is no such thing as scientific Roman medicine and what was brought in from abroad had soon to adapt itself to Roman ways. But, in general, thought on somatic needs, on medicine, formed only a small fraction of the philosophy which was engrossed with seemingly higher ideals, æsthetical, logical, and religious in turn. And in that small place left for medicine the concept of infection was not apt to thrive.

To enter into details here would lead us far astray. And details do not help us much, considered by themselves, outside of that connection which links them as intellectual phenomena to primordial concepts. That is a task for future historians. But one curious fact becomes apparent already, as we glance over the period: in times of greater

²¹ It is of some interest that Ruffer in his microscopic examinations of Egyptian mummies found the encapsulated or calcified schistosoma hæmatobium, and so demonstrated with certainty the occurrence of Bilharziosis in ancient Egypt.

emergencies such as wars and pestilence, the idea of infection asserts itself in its state of original simplicity. What share has the classical medical thought, with its fund of analyzed observation and experience, in this phenomenon? In the Hippocratic writings, in those of the Alexandrian school, we still detect the influence of the primitive concepts, but gradually they separate and follow different channels. Along with the roaring and sometimes turbid main stream of scientific thought runs the babbling, limpid brook of popular tradition, in which we readily detect the intuitive sources. Here and there they approach each other and sometimes a little runs from one into the other, but on the whole they proceed apart. The poet, the playwright, the philosopher, those spokesmen of folk medicine, the medical writer less and less, re-affirm the eternal validity of the primitive idea of infection whenever they dwell on times of grave danger.²²

The history of infection is usually begun with the period when the animate contagium became demonstrated to the satisfaction of exacting scientists. The cornerstones planted are Fracastoro in the sixteenth, Athanasius Kircher in the seventeenth century.²³ In a certain sense this is true, in another it may be shown that the history of infection as a broad concept of pathogenesis ended when the attempt was made to convert medicine into an exact science. The supreme effort in this direction is centered in Galen, the most industrious and ingenious prototype of the modern medical scientist. Whenever one examines his great work, and analyzes the reasons for the aggressive

and contemptuous attitude he assumed against all other thinkers in medicine, methodists, empirics and pneumatists, one is impressed by the logical sequence of his arguments, by his evident eagerness for objective examination in the solution of his problems, but one can not fail to see that he juggles with his premisses and assort his facts just to show the stupidity of the others and especially that of the "ass of Thessalos," his chief abomination, and that he is not above a feeling of jealousy towards those successful practitioners.

The differences between the opposing schools were formal rather than real, in theory at least, but the methodists were more ready to adapt themselves to Roman peculiarities which Galen scorned. This is brought out very well by Meyer-Steineg in his essay on Thessalos of Tralles²⁴ where he shows how the Roman always favored popular as against scientific medicine, and how cleverly this was exploited by Thessalos and his methodist *confrères*. Also how strong this Roman preference was so that even Galen had to submit to it in turn. Both parties in the conflict derived their knowledge from a study of the body and its functions, but both in different ways, wherefore they denied scientific consideration to each other. In common they neglected a broader ætiology. True, Galen had evolved logically an ætiologic system, but based it almost entirely on an elaboration of Hippocratic humoral concepts and the theory of innate qualities. He was too much absorbed by the variegated phenomena in the body and too much opposed temperamentally to the superstitious nature of external forces, to stress they start into life and take command. Dumb and invisible, some are yet our masters in all critical times."

²² From a review of Sir Bampfylde Fuller's new book ("Man as he is," London, Murray, 1916), in the *Times Literary Supplement* of Nov. 23, 1916, which I receive as I am reviewing my Mss. I find that he has come to similar conclusions: "With man as we know him, living in an artificial state, recollections of his experience count for more and more, and the primitive impulses for less and less. They are by no means dead. In certain circumstances of strain and

²³ For the details of this period see the painstaking review by Charles and Dorothea Singer: *The Development of the Doctrine of the Contagium Vivum, 1500-1750, Int. Med. Congr. Sect. Hist. Med., 1913, pp. 187-207.*

²⁴ *Arch. f. Gesch. d. Med., 1911, iv, 89.*

ever clearly see and admit the fact of infection, or at least its importance. "Who does not know, he exclaims, that brine and seawater preserve meat and keep it uncorrupted (aseptic, ἀσηπτα), whilst all other water—the drinkable kind—readily spoils and rots it" (διαφθείρει τε και σήπει).²⁵ But this did not suggest to him any external origin of this corruption. To him it is a spontaneous process, apt to occur also inside the body, just as the innate heat, which according to him has no outside source, as Erasistratos thought. Such facts as he notes them down serve him only to support ingeniously his humoral theory. For sixteen hundred years scientific medicine speculated and experimented on very similar lines.

The lay writers Celsus, Cato, Varro, Columella, Pliny, Vergil, Vitruvius and others note the fact of infection as a commonplace that needs no argument. Could any one express it more clearly than Lucretius in his famous poem, *de rerum natura*, which had such a great influence on the thought of the Middle Ages?

Primum, multarum semina rerum
Esse supra docui, quæ sint vitalia nobis:
Et contra, quæ sint morbo mortique, . . .²⁶

Had Galen seen in this and in Lucretius' *morbida ær* and *pestilenta* anything else but a poet's license, we would surely have a long treatise from him on the subject, and not only his casual references to the contagiousness of certain diseases. And still, in spite of Galen's science which was triumphantly to conquer the world, we find Ammianus Marcellinus, last but not least of Roman historians, telling that the Antoninian plague was caused by soldiers breaking into the tem-

ple of Apollo where Chaldean priests hid the morbid virus. Nergal, the god from Mesopotamia, still wants his voice heard in the matter!

This voice arises again and again as we traverse the coming centuries. Hardly perceptible in the scientific writings of the Middle Ages, though always traceable, it becomes more and more subdued by the one eager interest of Christian aspiration to use the knowledge of the world for the understanding of the Bible. Science becomes the handmaiden of theology: "Non potest intellegi sacra Scriptura sine aliarum scientiarum peritia," wrote Bonaventura.²⁷ And when modern historians claim that the turn of the tide came in those times with the introduction of the experimental method, hailing Roger Bacon and his "experimental science which neglects argument" as a sort of savior of science, it can not appeal to one who has heard the far cry for observation, experience and experiment from the dawn of human thought. It certainly is difficult to understand how such evaluation could ever be deduced from Bacon's naïve belief in the powers of this "new science" and its master, Pierre de Maricourt.²⁸ Infinitely more important it is to recognize in those times the profound social reorganization which is taking place, leading to powerful and multiple organizations of corporate interests, the mediæval townships and universities. This is more significant even than the setting free of the purer classical spirit after the capture of Constantinople, and its influence on arts and sciences, because for the first time an organized popular will asserts itself which henceforth cannot be neglected. Already it shows its creative possibilities in the measures for the protection of the public health. No careful student of the decrees of this

²⁵ Galen: On the natural faculties, B. II. 129, translation by A. J. Brock. London, Heinemann. N. Y., Putnam, 1916. Loeb's "Classic Lib."

²⁶ First, as I have said before, seeds of many things are vital to us; and again others that bring disease and death . . .

²⁷ "Epist. de tribus quæstionibus."

²⁸ See Henry Osborn Taylor's brilliant article on Roger Bacon in his "Mediæval Mind," London, Macmillan, 1914, vol. ii, 514.

time providing sanitary legislation, quarantine measures and disinfection against various diseases and especially plague, leprosy and phthisis, can fail to see how much all this is based on the fundamental concept of infection. Imperfect as are all human institutions these measures were often excessive and unnecessarily severe. Because of this inherent defect, which our own measures share, they hardly merited being held up to ridicule by Koehler at the International Conference on Sanitary Legislation in 1897. It is characteristic of the prevailing historical shallowness that he cited the mediæval decrees against cholera, a disease which first appeared in Europe only 100 years ago.²⁹

Many instances might be cited to show how often the lay mind, grasping a fundamental principle, drew instinctively and spontaneously the necessary consequences and it is somewhat depressing to have to acknowledge that so very often this occurred without the aid of the scientist and sometimes against his protests. But only the recognition of the fact can indicate the road to improvement. I shall not try to cite many instances but I cannot refrain from alluding to that last event in the history of infection, sufficiently remote to permit critical analysis, which shows the extraordinary viability of the primordial concept and its application. I mean the great experiment of prophylactic variolation during the period of from 1721 to 1840. It is almost forgotten over vaccination although neither the one nor the other owed its origin to scientific medicine. I shall merely repeat what I said before about the work of Angelo Gatti in which he gave expression to the thoughts underlying the movement, against the opposition of the Medical Faculty of Paris: First he discusses the ætiology of smallpox and turns sharply against such futile terms as "fermentation, leven, humores, ebulli-

tion, effervescence, germ, etc." On the meaninglessness of such terms a mass of physicians base their therapeutic procedures; they use them even in such cases where a Sydenham or Boerhaave would have been content to observe and describe. For Gatti variola is produced by a foreign body that has entered the organism from without. Transmission takes place by contact, or through the organs of respiration or digestion. The "virus" reproduces and multiplies itself. Smallpox is the constant and definite effect of it, strictly specific. Variolation is the transmission of the disease controlled by intelligence instead of accident. For the purpose of inoculation the virus must be modified. Gatti's purposeful attempts at attenuation might still be read with profit by modern experimenters.³⁰

CONCLUSIONS

We are too near our own time to form a broad judgment of our methods and concepts. When we review the many fertile applications made by microorganic biology in every-day life, the advances of a purposeful prophylaxis and of sanitary sciences generally, to doubt the correctness and utility of these efforts would require a hypercritical and entirely objectionable attitude of mind. And also as regards our modern methods of laboratory investigation, we must agree with Welch, when he said here at the University of Chicago in 1907, that "we cannot foresee a time when purely observational and descriptive biological studies, which to-day hold the first place, shall not continue to have their value."³¹ It is probably better in the interest of our aims that we should rather over- than

²⁹ See G. Sticker in Heft 2, *Zur historischen Biologie der Krankheitserreger*, Giessen, 1910.

³⁰ A. C. Klebs, Heft 7. *Hist. Biologie d. Krankheitserreger*. Giessen, 1914, also *The historic evolution of variolation*, *Johns Hopkins Hosp. Bull.*, 1913, xxiv, 69.

³¹ Welch: *The Interdependence of medicine and other sciences of nature*. *Science*, 1908, Jan. 10.

under-estimate the absolute value of our methods and achievements. In the wider realm, just as in individual life, an insidious dwelling on the past may lead to paralyzing speculation, self-depreciation and hesitation. Here as there, such tendencies must be discountenanced. But, on the other hand, it can not be denied that the taste for self-exaltation, rampant to no small extent, merits equal attention, as it may easily lead to overindulgence and mental indigestion.

Viewed with this general proviso it may perhaps not be unprofitable to picture the impressions a future historian might gather from a perusal of our bulky literature. Would he see that the elaboration of the doctrine of the specificity of cause and effect in infectious diseases, which "*de tout le temps toutes langues ont dit*" as Bretonneau put it, already in 1855, has led us to a deeper and more correct comprehension of these diseases? May he not conclude that we have not drawn from it the full logical consequences, that we have persistently disregarded our negative findings and, in overestimating the importance of the positive ones have come to a sterile generalization of contagionism? Will he admire with Sticker the courage of Pettenkofer when he insisted, in his famous cholera doctrine, less on what he had determined and knew, than on what he *did not know* and what needed to be brought out? Or, will he brand him, with Liebermeister, as "a subtle and sometimes humorous dialectician," notwithstanding the solid results obtained as a consequence of Pettenkofer's and others' sanitary reforms?

It is worthy of serious reflection whether the day is not likely to come when those efforts now occupying the center of the scientific stage, that is, the search after the specific microorganism, its minute identification by complex experimentation and the prophylactic and therapeutic application derived therefrom, will be relegated to a less conspicuous place. We admit contributory

causes, but by their very subordination we show how difficult it is for us to see in them anything but unimportant influences. And we forget that it is only the obviousness of one factor and the lacking clearness of the other which determine the artificial subordination. Pettenkofer's *x* we have found but the equally important *y* and *z* have yet to be supplied in the ætiologic formula.

Shall we desist from this deeper ætiologic search because of intrinsic difficulties? The reserved position of Virchow and Cohnheim toward it will be recalled. To them ætiology seemed too vast a subject, involving too many different factors and technical methods which could not all be fitted into one scientific garment. Hence they persisted in observational and descriptive methods. Koch and his school of technical artists, without any such restraint but also without the broad outlook of their predecessors, were heralded as the founders of a new medicine. Their historian, Abel, describes the final triumph in these eloquent words: "Laboriously, slowly and late, but at last with certainty, the pure contagionistic theory has attained to the sole rulership in science." All this in barely forty-five years and based almost entirely on technical and instrumental improvements. The "sole ruler" is difficult to please, a failure to solve some particular problem is invariably put to faulty or inadequate technic, never to a wrong direction of effort, and the object of research, may it be the infecting organism or its carrier, must remain unalterably the same. We look down upon the mediæval scholar who attempted the solution of similar problems by syllogistic structures of thought based upon insufficient facts. We have undoubtedly more facts, but can we prove their sufficiency by subtleties of experimental research, so often unrelated to actual exigencies? Multiple facts brought out by inductive research do not combine, as Francis Bacon expected they would, infallibly leading to really useful gen-

eralization. Never yet in the world's history has a great progress, a discovery of fundamental importance, been achieved by this method.

There are some signs of a reaction against the present concepts and methods of pathology. It is no more a cellular pathology in Virchow's sense. The doctrine of the cell as the vital unit, one of the most useful generalizations in biology, does not rule pathology any longer. The limits of cellular autonomy and the interdependence of the units, only dimly admitted by Virchow, are becoming better defined. The concept of the organism as an entity (also in its pathological phenomena) and of its essentially fluid constitution opens a wide outlook through the work of W. Roux, Jacques Loeb and Albrecht. In accord with these modern concepts, it was one of the pioneers of ætiologic research, Edwin Klebs, who defined infectious disease as the resultant from the interaction of different bodies, yielding different products and phenomena. And he al-

ready postulated, as of prime importance, that all processes within the sphere of living bodies just the same as in that of the non-living, must take place according to the same fundamental laws; that, therefore, also in pathology, there is no room left for a special vital force.

In all these newer tendencies the interdependence of medicine and the other natural sciences becomes ever more clearly visible. It will need the work of genius to bring about the needed efficient interaction. We may have to wait long for such an one. Meanwhile the common ground might be prepared, and we believe that nothing can do it so well as organized historical research in science, because, in George Sarton's admirable words: "Science, divided into water-tight compartments, makes us feel uneasy;—a world split into selfish and quarrelsome nations is too narrow for us. We need the full experience of other countries, of other races; we need also the full experience of other ages. We need more air!"